SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JULY 1920.

GENERAL PHYSICS.

957. *Adjustment of Time Error between Clock and Observer.* **K. Sôtome.** (Phys. Math. Soc. Japan, Proc. 2. pp. 69–78, April, 1920.)—The assumption usually made is that irregularities of apparent clock rate, as shown by astronomical time determination on different nights, are due entirely to the clock. The author thinks that the Riefler clock is so much more accurate than those previously in use that much of the apparent change of rate must be attributed to errors of observation or change of personality. He has worked out the probable ratio of the two parts of the error, A and B (due to observer and clock respectively) on the five possible assumptions (A = 0; B = 0; A and B of same sign; A +, B −; and A −, B +), and concludes that the most probable assumption is that A and B have the same sign and A = 2B.

He applies the same test to the Washington–Paris longitude worked out in 1913–14, in the cases A = 0, A = B, and A = 2B; comparing them with the adopted curve method showing that the introduction of A and B is better than the old style of B only (A = 0), but for European and American observers A = B gives a better result than A = 2B found by Japanese observations. This points to greater accuracy of the European and American observers. The author considers that his new method avoids the "personal" element in the curve method, as it is worked by a concise formula. W. W. B.

958. *Experiment in One-piece Gun Construction.* **P. W. Bridgman.** (Am. Inst. Mining Eng., Bull. No. 158. (16. pp.) Feb., 1920.)—The fact that in hollow cylinders subjected to internal pressure the max. stress occurs in the inner layers, causes these layers to fail long before the outer layers have reached their limit of capacity. Economical use of the material demands that all parts of the cylinder shall reach the limits of their capacity simultaneously, and this is brought about in cylinders of not too great thickness by producing an initial compression in the inner layers and an initial tension in the outer layers. In gun construction this initial distribution of stress is obtained by wire-winding the inner tube (English practice) or by shrinking hoops over the inner tube (American practice).

Another possible method is by subjection to great internal pressure which causes the inner layers to flow and the outer layers to stretch. On release of the pressure the outer layers shrink back on the inner and produce an internal compression and an equilibrating tension in the outer layers. By this means it is possible to raise the elastic limit to two or three times the value calculated by the usual theories. An arrangement is described for the application to a 3-in. gun, of an internal hydrostatic pressure high enough to strain the material beyond its yield-point. After treatment and machining firing tests gave very satisfactory results, and it is expected that the adoption of this simple method of construction will lead to important economies particularly in time in quantity production. During the initial stretching there is no evidence of an elastic limit, the stress-strain (increase of external diameter) curve showing pronounced curvature. On repeated stretching the cylinder received little or no further permanent set up to the previous max. pressure. Hysteresis and accommodation effects are very prominent. F. C. A. H. L.

959. *Fluid Flow.* **C. Camichel.** (Comptes Rendus, 170. pp. 881–882, April 12, 1920.)—Further examples, including a verification of the continuity equation, are given of the experimental method for studying fluid motion by intermittently illuminating the stream charged with light powder. The particles carry a bubble of air, and those whose densities are equal to that of the fluid are carried along with the stream. Two photographs taken at known times form the basis for measurement. W. A. R.

960. *Elastico-Viscous Flow.* **A. A. Michelson.** (Nat. Acad. Sci., Proc. 6. pp. 122–127, March, 1920.)—The formula for the displacement produced by a stress is modified to suit experimental facts. Further modification is made to correspond with the probability that the viscosity is largely internal (due to the relative motion of parts). It is pointed out that, whilst the term involving a permanent set may have no application to the problem of earth tides, it cannot be neglected especially when temperatures approaching the melting-point of the material are in operation. A provisional table of constants for many materials under torsional strain at room temperature is given. W. A. R.

961. *Physics of Flight.* **D. L. Webster.** (Frank. Inst., J. 189. pp. 553–580, May, 1920.)—Discusses the physical theories underlying the various conditions met with in practical aviation, *e.g.*, the problem of rising out of a small field by "zooming," the effect of gusts, "air-pockets," etc. The theory of stability is also dealt with in general terms. J. W. T. W.

962. *Measurement of Time.* **L. Silberstein.** (Phil. Mag. 39. pp. 366–372, March, 1920.)—The author here refutes N. Campbell's objections [Abs. 189 (1920)] to the arguments of his former paper [Abs. 190 (1920)]. He neither said nor meant to imply that methods independent of space measurement were impossible. He justifies his statement of the principle underlying common time scales, showing it to be not only logically justifiable but historically true. In short, every precise chronometry is kinematical (motion of bodies or propagation of light), and the foremost concept of kinematics is that of *uniform motion,* exactly so as is that of *straight*

line in geometry, both terms being essentially indefinable. The fallacy of Campbell's proposed basis of measurement—for time or any other magnitude—with its three definitions, is clearly exposed. In conclusion, the author observes that it would be interesting to see an attempt, on Campbell's lines, to set up an intrinsic scale of temperature or of length, especially the latter, and suggests that the psychological clue to all his fallacies is contained in his concluding sentence: "Of course this is all as elementary as A B C," and puts the query: If this were so, gigantic mentalities, such as was Cayley and many of his successors here and abroad, would never have devoted so much time to what is known as the theory of distance. G. W. DE T.

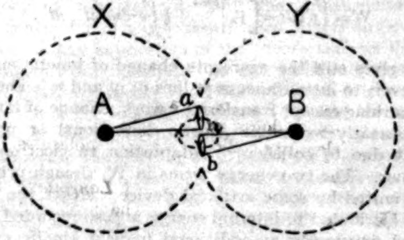
963. *Form of Ultramicroscopic Platinum Particles.* **R. Gans** and **R. Calatroni.** (Ann. d. Physik, 61. 5. pp. 465–470, March 3, 1920.)—Like gold and silver amicrons [Abs. No. 1199 (1915)], those of platinum also are approximately spherical [see Diesselhorst and Freundlich, Abs. 1090 (1916)]. T. H. P.

964. *Cohesion, Internal Pressure, Adhesion, Tensile Strength, Tensile Energy, Negative Surface Energy, and Molecular Attraction.* **W. D. Harkins.** (Nat. Acad. Sci., Proc. 5. pp. 562–568, Dec., 1919.)—The author discusses various considerations relating to the following thermodynamic equation, which gives what he terms the total adhesional energy, *i.e.*, the total energy involved in the approach of two unlike surfaces: $E_A = -\Delta E = (\gamma_1 + l_1) + (\gamma_2 + l_2) - (\gamma_{1,2} + l_{1,2})$, where γ_1 and γ_2 denote the free energy of the two unlike surfaces before their approach and $\gamma_{1,2}$ the free energy of the interface.

As regards the assumed existence of a negative surface tension or free surface energy, the author's investigations show that the discovery of a negative free surface energy for a plane uncharged surface is improbable, although it is likely that such a phenomenon exists with highly curved phase boundaries. In conjunction with E. C. H. Davies, the author has, however, discovered a negative total surface energy for a plane uncharged surface. Thus, contrary to the rule formerly found to hold, the surface or interface between octyl alcohol and water gives off energy when it is extended but, nevertheless, the surface cannot be formed without the expenditure of work. This apparent contradiction is due to the fact that while the molecular motion aids in the formation of an ordinary surface, in the case of the interface mentioned the molecular motion hinders the extension of the surface. T. H. P.

965. *Bending on Positive-Ray Hydrogen Parabolas.* **F. W. Aston.** (Cambridge Phil. Soc., Proc. 19. pp. 317–323, Feb., 1920.)—Bendings at points corresponding to energy greater than the normal have been satisfactorily accounted for by multiple charges, in J. J. Thomson's monograph, *Rays of Positive Electricity*. The author's experiments, carried out with a large canal-ray tube and visual observation with a willemite screen, with which the H_1 and H_2 parabolas were easily seen even with the less effective types of kathode. The appearances on the screen were soon seen to consist of the superposed effects of atomic and molecular types of discharge, the effects of which could be distinguished by varying the kathodes—convex ones, while least efficient, giving the molecular type with the least atomic blurring, and the more efficient concave ones giving a practically pure atomic type under a moderate range of conditions. The additional secondary streaks, called "satellites" by the author, to those accounted for by Thomson can be explained, as regards the atomic type of discharge, by a + charged H atom striking and capturing a neutral one, relatively at rest, which will give rise to a molecule of double its mass, but with the same momentum if the collision be inelastic. As regards the molecular type, the author's explanation—somewhat similar to Thomson's—is as follows: The collision with and capture of a single − electron by a + charged molecule will not necessarily merely neutralise it and cause it to hit the central spot, but may result in its splitting into two atoms with + and − charges. Atomic ions appear to be formed by the passage of kathode rays through the Crookes dark space, molecular ones mainly in the negative glow. The primary molecular rays practically disappear when the pressure in the tube rises to a certain extent, which the author suggests may be explained on the somewhat speculative assumption that molecular rays can originate freely only in parts of the discharge where the electric force is very small, *e.g.*, the negative glow, ionisation by more violent means in strong fields tending to cause simultaneous disruption of the molecule. This agrees with the observed fact that, in general, true primary molecular arcs are shorter than atomic ones. It would also mean that a very short arc infers as origin a molecular disruption, which would agree with the conclusion that X_3 is molecular, since it appears on the photographic plate as a short arc. The visual evidence on the screen leaves little doubt of a similar formation of satellite arcs by atoms of heavier elements colliding to form molecules. G. W. DE T.

966. *Cubical Atom Theory of Lewis and Langmuir.* **I. Langmuir.** (Nature, 105. p. 261, April 29, 1920.)—The author deprecates S. C. Bradford's reference to the cubical atom theory [Abs. 500 (1920)] as Langmuir's theory. Although G. N. Lewis [Abs. 946 (1916)] implied stationary atoms, his theory of valency did not depend on this assumption. Chemically, the electronic motions are comparatively indifferent so long as they conform to the required condition of symmetry, for which reason the author, in his extension of the theory [Abs. 991 (1919)], stated that the electrons in atoms are either stationary or rotate, revolve, or oscillate about definite positions in the atom. The success of Bohr's theory does not justify belief in coplanar orbits. Chemically the theory is wholly unsatisfactory when applied to atoms containing more than one electron, *e.g.* [Abs. 15 (1914)], it gives no reason for the contrast between the properties of Li and He. But the two theories are not incompatible if we consider, in general, that the electrons revolve, not about the nucleus, but about definite positions symmetrically distributed in three dimensions about the nucleus. Born and Landé [see Abs. 528 and 530 (1919)], starting from Bohr's theory, and without knowing Lewis's work, were led to the theory of the cubical atom by a study of the compressibilities of the alkali halides. They conclude that the electron orbits are not coplanar, but arranged in space with cubic symmetry. Sommerfield in his recent book, "Atombau und Spectral-linien," suggests that this conception may help to solve some of the outstanding difficulties. Where atoms do not share electrons, it is logical to assume that each electron in the outer state has its own orbit, *e.g.*, the atoms Ne, Na +, Mg + +, F −, and the S atom in SF_6 should have cubic symmetry, the eight outer electrons revolving about positions located at the corners of a cube. When a pair of electrons is held in common between two atoms, the chemical evidence indicates that the pair acts as a unit. When an atom shares four pairs of electrons with its neighbour, it should have tetrahedral rather than cubic symmetry. Chemically, Bohr's model for the H-molecule would satisfactorily explain the pair of electrons constituting the chemical bond. The author thinks some facts of vital importance are still missing in Bohr's theory. The chemical data suggest that the ultimate theory will be extremely simple, but perhaps more radical than anything yet proposed. **A. E. Oxley.** (*Ibid.*, 105. pp. 327–328, May 13, 1920.) Oxley points out that Langmuir's construction—closely allied to Bohr's—for the H-molecule would make molecular H strongly paramagnetic, and suggests the following construction giving a diamagnetic H-molecule. Suppose X and Y are two exactly similar hydrogen atoms. Their nuclei are shown at A and B, and the negative electron orbits at *a* and *b*. The nucleus A may control the orbit *a* electrostatically and magnetically, while B controls *b*. As shown, there will be magnetic attraction between *a* and *b*, and possibly also a certain amount of electrostatic repulsion if each electron is not completely bound to its own nucleus. Equilibrium may be established for some such disposition of the charges as that indicated. We thus get a sort of fusion of the two hydrogen atoms which corresponds to the fusion of the electron orbits in Bohr's theory of the hydrogen molecule. In the present case, however, the fusion is controlled magnetically, whereas in Bohr's theory it is purely electrostatic. One can see, in a general way, how the small circular orbits would, in more complicated systems, dispose themselves in pairs, as in the Lewis-Langmuir theory, but now primarily under their neutral magnetic influence. And it might be expected that the electrons would be drawn by mutual magnetic forces into a space-pattern, characteristic for each molecule, the symmetry of which would be reflected in the crystalline symmetry. This would explain the close connection, observed by Tyndall, between the deportment of crystals in the magnetic field and the disposition of the planes of cleavage. Possibly each of the nuclear orbits shown in the diagram might be identified with the Parsons ring-electron, although with quite a different conception of the H-molecule. G. W. DE T.



Model of hydrogen molecule.

967. *Alternative View of Relativity.* **F. Slate.** (Phil. Mag. 39. pp. 433–439, April, 1920.)—In electronic dynamics, reasoning based on the narrowed Newtonian scheme resting on a statement of Newton's second law for constant inertia, supported by a principle of *vis viva* requiring all work to be recorded as change of kinetic energy, is foredoomed to failure. Is it not one typical or even unique function of the electron to effect reversible transformations between mechanical energy and field-structure? Restoring duly general form to Newton's relations for energy, momentum, and force, leads directly to an adjustment of relativity and Newtonian dynamics, eliminating alleged contradictions and re-establishing them as properly equivalent procedures. Consider a single electron in accelerated rectilinear motion and in electromagnetic field forces. Let M be the variable inertia, T the tangential force with respect to a reference frame F. Then $\mathrm{T}=m\dot{v}+v\dot{m}$. . . . (1). With respect to a frame U having unaccelerated translation u colinear with v, the so-called Newtonian transformation is invalid, and an apparent force, T_a' will be determined in relation to the observed force T_o by $\mathrm{T}_a'+u\dot{m}=\mathrm{T}_o$, significantly parallel with $\mathrm{W}_1+m_1r\omega^2+\mathrm{G}_1$, connecting weight and gravitation at the equator, where they are collinear. Writing W for work and E for (molar) kinetic energy,

$$\mathrm{W}=\int_o^t v\mathrm{T}dt=\Big[\mathrm{E}\Big]_{t=o}^{t=t}+\tfrac{1}{2}\int_o^t v^2 dm/dt \,.\, dt \quad . \quad . \quad . \quad . \quad . \quad (2).$$

The first term gives still the aggregate change of kinetic energy, accommodated, however, to instantaneous values of m and v. The second term can represent nothing except transformed work, change of internal energy, which may be nearly reversible (elastic distortions) or practically unreversible (heat due to collision). Adaptation to electronic conditions means the former. The two energy terms in W, though primarily separated, may be united by some artificial device; either the actual molar energy may be attributed to internal energy and so recorded, or the latter may be entered fictitiously as additional (molar) kinetic energy. Both coalescences are mere book-keeping, exemplified also in the "two specific heats" of a gas. Relativity has exploited this open chance in handling energy equations. Now assume for m the experimentally suggested law $dm/dv=mv/(c^2-v^2)$, $\dot{m}=mv\dot{v}/(c^2-v^2)$ . . . (3), and write $m_o\equiv[m]_{v=o}$ for the frame F, and $\gamma(z)\equiv(1-z^2/c^2)-\tfrac{1}{2}$, c being light speed in F. Then $\mathrm{T}_o=m_o\gamma^3(v)\dot{v}$; $\mathrm{W}=c^2m_o\{\gamma(v)-\gamma(v_o)\}=\tfrac{1}{2}\int_o^t v^2\dot{m}dt+\Big[\mathrm{E}\Big]_o^t$ . . . (4).

Here the kinetic energy changes from W in virtue of equations (3) which assume an entirely electromagnetic origin for electronic inertia. The work would then be entirely absorbed in field-building. Further, it appears that it may enter as an algebraic sum, including changes in electric and magnetic field, and the release of internal energy seemingly occurring in a deformable electron. Hence the integral must represent a difference between changes in structural and kinetic energies, and with suitable standardisation of its zero-phase, must be in nature a kinetic potential. If M_o be identified as the "Minkowski mass," equations (4) become formally identical with corresponding relativity equations, as also the momentum value $\mathrm{Q}\equiv mv=m_o\gamma(v)v$. But in the relativity interpretation m_o is constant, and frame may be F or the group U; in the Newtonian, m is variable and frame is F uniquely. Further consequences of relativity's indifference will be found in imaginary force and quaternionic velocity. If now T_a', v', referred to U, correspond to T_o, v referred to F, and we write $\mathrm{V}_c'\equiv(v-u)/(1-uv/c^2)$, it follows that $v\mathrm{T}_o=v_c'\mathrm{T}_a'$,

$vT_e = \gamma^2(u)(v_e' + u)T_e'$, reproducing " Einstein's theorem " with an altered meaning, furnishing a rule for making compensations in activity for disturbed value due to passing from F to U. Reversing the procedure will correct a distorted estimate in F of measurements made in U, and taking the established rule for superposition of colinear " Lorentz transformations " in this sense, any linked succession of repeated distortions from original data can be traced through the frames U, and the net compensation at any stopping point determined. A similar analysis for the tangential force leads to a transformation formally identical with that of the " Minkowski-force " K; Minkowski's " proper time," not " local time," replaces fluxion time *t*. The work equation proves equally tractable, and the author claims that all this puts in hand a complete control for a new aim of the whole system of calculative detail that flies the flag of " non-Newtonian mechanics." G. W. DE T.

968. *The Causal Demands of Relativity and Einstein's Relativity Theory.* **H. Holst.** (K. Danske Vidensk. Selskab. 2. No. 11. pp. 1–64, 1920.)—One of the main causes of the strong resistance offered to Einstein's theory of relativity is that the dimensional changes of bodies and the continuity of physical processes appear to be incompatible with causal laws. Many supporters of the theory such as Petzoldt admit that the ordinary causal demands are not satisfied. It appears also, that the special relativity theory has afforded decision to most physicists as to whether the older causality principle should be abandoned or Einstein's principle of relativity rejected. Many investigators have sought to combine the assumption of Einstein as a generalised principle of phenomena with the causal conception, by retaining the universal ether and adopting the view of FitzGerald and Lorentz that in motion relative to the ether a contraction in the direction of motion is experienced. Lorentz has also shown, that by a very simple hypothesis as to the nature of the forces between the parts of the body and the behaviour of electrons moving in the ether, the ether theory may be brought into harmony with Einstein's hypothesis. The present author discusses this view at length from the standpoint of its weakness, namely, the introduction of the material ether idea itself. Einstein's work on the special and general theory of relativity is then briefly discussed. In the present paper the author assumes that motions or positions in physical processes must not be referred either to empty space or to a hypothetical universal medium, but must be relative to discernible bodies or to parts of space differentiated from the surroundings, or otherwise, that only such bodies can be regarded as carriers of physical causes. The meaning of relativity is then examined. The author believes that causality will again come to the fore through development of the general theory of relativity, and he considers that existing difficulties are due to Einstein not having made the causal argument the main issue. The author regards Einstein's success in establishing general co-variant expressions for general physical laws as a remarkable result. He then investigates the results to be attained when the causal demands are satisfied, and shows that, without employing the special methods and assumptions of Einstein's theory, many of the results of the relativity theory are to be obtained from simple considerations. He then attempts to show that no essential contradiction exists between Einstein's theory and the older physical conceptions. For this purpose the field-producing system of the material universe has been investigated and its formation of a neutral field in the space concerned. The paper concludes with a discussion of the possibility of ascribing infinite extent and mass to the material universe. H. H. Ho.

969. *Gravitation and Light.* **J. Larmor.** (Cambridge Phil. Soc., Proc. 19. pp. 324-344, Feb., 1920.)—Newton's view of the relation between light and gravitation as modified by John Michell [Roy. Soc., Phil. Trans. 1767] is paralleled with curious closeness in certain modern physical speculations. This subjection of light to gravitation would make its velocity exceed the limit *c*, which on electrodynamic theory is unattainable by a material body. But this limit arises from supposing that the inertia of a material body increases indefinitely with the speed, the *quantum* of energy in the hypothetical light-bundle remaining sensibly the same. The view of centrifugal force which arose forty years ago represents it, not as a force of Nature, but as the reaction postulated, in the scheme of Newton's third law and its Scholium which so widely reached forward towards modern theory, to balance an imposed centripetal acceleration, and the scheme would then assert that the forces of nature that act as the framework of a material body and the forces of reaction that are thereby induced in it, form together a system of forces that preserve statical equilibrium *in relation to* the constraints of that framework, as tested by the principle of virtual work. The principle of relativity of forces, advancing on the same lines, suggests that all force, gravitation included, may be expressible as reaction against acceleration, like the obviously unreal centrifugal. If any form of reference could be found to satisfy this condition, forces would disappear and the principle of least action would make orbits simply the shortest paths in the frame. Neither the Newtonian uniform time and space nor the Minkowski fourfold permit this transformation. Einstein's idea of the relativity of gravitational forces raised the problem whether the fourfold, deformed into a non-uniform and therefore non-flat heterogeneous space, will permit it. Perhaps it goes even further, and asks whether, if not, there can be some other corpus of abstract differential relations invented, that will transcend the notion of spacial continuity altogether, but will in compensation for that formidable complexity succeed in effecting this object. The successful merging of the forces of nature into spacial relations would account for their measurability in terms of second gradients, in that the curvature of a deranged space is expressed by a measure which does not involve higher gradients.

This hypothesis as to gravitation, which makes it identical in its nature with the apparent increase of weight experienced by an observer in going up in a lift with accelerated motion, raises questions regarding the relation of gravitation to physical agencies such as light, the answers to which may be ambiguous until yet further postulates intervene. After referring to Einstein's prediction of a shift towards the red of the lines in the spectrum of solar H, as compared with terrestrial H, and the grounds which he gave for it in his 1911 preliminary theory and his later formal theory, respectively, the problem is investigated, the argument proceeding, in the first place, on the assumption that the mathematical analysis must establish a complete correspondence, element for element, between the activities in the new space-time and in the Newtonian space and time. With Minkowski, the very incomplete relativity of electrodynamics is crystallised into the proposition that events occur in a uniform fourfold time-space, determined by the constitutive spacial equation $\delta\sigma^2 = \delta x^2 + \delta y^2 + \delta z^2 - (c\delta t)^2$, where c has nothing to do with the speed of radiation, but is merely a dimensional factor, prescribing a scale of measurement needed to make time homogeneous with length, and may be taken as unity. It then follows, by comparing the general variational Least Action Lagrange-Hamilton equation of an orbit in a field of force with the equation of a geodesic in a modified fourfold involving Euclidean space combined with a measure of time varying with locality, that the forces can be absorbed into a varying scale of time, and that the orbit is a geodesic, or straightest path, in the uniform fourfold of relativity as slightly deranged by the not quite constant scale of time. It ought, however, somehow to be restricted to gravitation with its inverse square law, and here Einstein's theory comes in. For velocities beyond astronomical experience, not small compared with that of light, mass comes to depend on speed, and so is no longer a definite dynamical constant. On an earlier uniform relativity, however, it emerged as a feature of every permanent collocation of energy E and of amount E/c^2, provided Least Action is fundamental. Thus it is grouped energy that possesses located momentum, and must gravitate. Hence general dynamics cannot be more detailed than a mere description of the migration of energy and momentum in a medium under an internal stress adjusted to fit the equations most simply. This stress it is which will represent the energies of nature. But no law of elasticity is involved, or relation of stress to strain, such as makes elastic problems determinate, so the idea of a physical medium may be avoided by calling the stress an algebraic tensor. When the fourfold frame is very nearly flat, the energy-momentum-stress relations appear to fall in with the law of gravitation. When the deranged spacial frame nowhere differs much from the flat, the positional part of the extension will be very slightly non-uniform, and so not quite Euclidean. The fact that the speed of transfer of radiation energy in undisturbed space is equal to the merely dimensional constant that renders time comparable with space in the fourfold frame of reference is as yet unfathomed; but it certainly suggests a dynamical origin for that mixture of the effective relations of time with those of space.

Passing on to physical considerations and attempting to introduce the idea of wave-fronts and phases, we are faced with the difficulty that the velocity c is far too great for the new approximate gravitation analysis to be applicable, and in the finally developed theory there seems to be no longer energy of motion or other types: energy becomes a single analytic scalar in what is left of the field of interplay of momentum, energy and stress. The spectrum shift seems definitely negatived in that, according to our initial assumptions of complete correspondence, all time intervals measured at any element are changed in the same ratio depending on the locality alone. Any other conclusion would make the pulsating rays into signals establishing absolute time throughout the apparent universe, which could hardly be a result of a theory of relativity. Seeking a closer realisation of these abstract positions by aid of the Gauss-Riemann theory for an ordinary curved surface, the conclusion which emerges is that:—What remains of the original notion of relativity coincides with the principle of Newton, Faraday, and Maxwell, originated by Descartes, that the operations of Nature are elaborated in fourfold extension according to a scheme purely differential, that is by transmission from element to element of the cosmos, in no case leaping across intermediate elements as action at a distance would imply. The early stage of formulation of the confused notion of relativity is the postulate that position and change of position are purely relative: the final solution is to abolish the idea of immediate *finite* change of position altogether. But that does not imply that a portion of the cosmos can evolve itself without constant interference from all the rest. The aim of absorbing gravitation in space is not primarily to reduce gravitation to a quality of space—perhaps is not even relativity, which has evaporated—but is to get it out of Newtonian space and time into the mixed space-time fourfold so strongly suggested by Maxwell's electrodynamic relations of free space, and would make that scheme valid for great velocities of convection beyond experience, even up to the speed of light. The interlacing of space and time for purposes of electrodynamics having upset the historical development of dynamics on a Newtonian basis of separate space and time, order has to be reconstituted by piecing together a cognate analytical scheme on a symmetrical fourfold basis which *tries* to make no difference between them.

The mathematical analysis has *not*, however, established the complete correspondence so far assumed. There is a gravitational correspondence into which radiation and its rays do not enter. Under the special circumstances when the coordinate x_4, treated as a *quasi*-time, is not explicitly in the space specification, every beam of radiation carries with it a scale of x_4 throughout its course. It is the alleged measurement of this abstract coordinate by a travelling clock, which connotes a physical system, that is a main source of confusion. The mere fact that under these postulated circumstances isotropic vibratory radiation exists with its absolute velocity c is sufficient, not only to determine absolute measurements both in space and time, at every locality in the extension, but also to determine the rate of motional changes of the coordinates as referred to the uniform space-time of the radiation. It is gravitational correspondence, subject to this general control of the whole range of space-time by observations of light, with its isotropic and uniform qualities, that has led to verifiable conclusions. It is argued further that under these circumstances a ray belonging to a definite molecular period at the sun, will have changed when it reaches the earth, so as to agree no longer with that period as reproduced by a local vibrator; and that if the influence of gravitation on spectral periods were definitely disproved, it would appear, that, excepting to some degree a formulation of the original Nordström type, any hope of bringing orbits into direct relation with the electrodynamic space-time fourfold would have to be abandoned. The spectral shift law deduced is true only to the first order, but applies to any law of potential, and is irrespective of any special energy-tensor theory. The other two verifiable effects, the influence on the planetary perihelia and the deviation of light passing near the sun, arise partly from first order and partly from second order causes. Unlike the previous one, their exact verification is thus a test of the special theory of Einstein, or the equivalent Least Action formulation. Its original recommendation was that it restricts the universal forces of Nature to the one type of gravitation. G. W. DE T.

970. *Radiationless Orbits.* **E. B. Wilson.** (Nat. Acad. Sci., Proc. 5. pp. 588–591, Dec., 1919.)—Starting with Lorentz's expression for the reaction on an electric charge due to non-uniform motion, the author determines the types of orbits which are non-radiating in the sense that this force, being normal to the path, does no work. From the point of view of electromagnetic theory the rate of radiation varies as the square of the acceleration and can never vanish in accelerated motion; and there is a coordinate radiation of momentum. From the relativity point of view the rate of radiation of energy (and momentum) has been shown to vary with the square of the generalised curvature of the path when regarded as a space-time locus in four dimensions [see Abs. 328 (1913)]. For any real motion, where the velocity is less than that of light, the radiation must be positive, and radiationless orbits, other than straight lines uniformly described, are impossible. If, however, velocities greater than light were possible and if the formula for the rate of radiation still held, the orbits would be those for which the curvature vector was a minimum line. In view of their mathematical interest, these orbits also are determined, and it is found that, where R is the radius of curvature (in ordinary space) and the units are so chosen that the velocity of light is unity, the orbit will be determined by the equation $(dv/ds)^2 = (v^4 - v^2)/\mathrm{R}^2$. Hence $v = \sec. \int (ds/\mathrm{R})$, so that if any space curve be given intrinsically by the equation $\mathrm{R} = f(s)$, this equation will determine the velocity at which the curve must be traced if there is to be no radiation as determined by the usual electromagnetic formula. G. W. DE T.

971. *Einstein Gravitational Deflection of High-speed Particles.* **L. Page.** (Nature, 105. p. 233, April 22, 1920.)—The author agrees with Eddington's criticism [Abs. 513 (1920)] of his conclusion that a particle travelling with the velocity of light would be undeflected, which he here shows to be based on an insufficiently close approximation, and therefore erroneous. G. W. DE T.

972. *Parametric Solutions of Fundamental Relativity Equation.* **E. T. Bell.** (Phil. Mag. 39. pp. 285–288, March, 1920.)—It is shown that the equation $ds^2 = \Sigma a_{ij}\, dx_i\, dx_j\ (i, j = 1, 2, 3, 4)$, in which the a_{ij} are functions of the x_i, can be solved very simply by assuming that s, x_1, x_2, x_3, x_4 are functions of four arbitrary functions $\xi_i \equiv \xi_i(u)\ (u = 1, 2, 3, 4)$, when u is a parameter, and the method can obviously be applied to other equations of general dynamics. G. W. DE T.

973. *Relation between Wind and Gradient in the Lower Atmosphere.* **C. E. Brazier.** (Comptes Rendus, 169. pp. 730–733, Oct. 27, 1919.)—With the object of bringing into prominence the effect, if any, of the lapse rate of temperature in the vertical on the angle the wind makes with the direction of the pressure gradient, an examination has been made of 7-hour observations made during the 20 Decembers 1889–1908 at the Bureau Central Météorologique and at the top of the Eiffel Tower (300 m.). They were grouped according to gradient and lapse rate and a table gives the mean value in each group of the angle in question, both for the Bureau Central and the Eiffel Tower. Near the surface, for a given gradient, the wind approaches the isobar as the lapse rate increases, the variation in direction for a given variation in the lapse rate being greatest with weak gradients. For a given lapse rate, on the other hand, the wind approaches the isobar as the gradient increases, the change for a given change of gradient being the more marked the less the lapse rate or the greater the inversion of temperature. At the top of the Eiffel Tower variations in the angle corresponding to changes in the lapse rate are much less than at the surface, but it is clear that for a given gradient the wind approaches the isobar as the lapse rate grows less, the opposite effect to that at the surface. The result, due to Angot, that there is a marked diurnal range in the angle between the wind at the surface and the top of the Eiffel Tower with an afternoon minimum and an early morning maximum is shown by the present work to be attributable to a diurnal redistribution of temperature in the vertical, and there is now the further result that for a given lapse rate the angle is smaller the steeper the gradient. M. A. G.

974. *Ratio of observed to Gradient Wind in the Lower Atmosphere.* **C. E. Brazier.** (Comptes Rendus, 169. pp. 869–871, Nov. 10, 1919.)—In a previous paper the effect of the lapse rate of temperature on the angle between the observed wind and the direction of the pressure gradient has been demonstrated [see preceding Abstract]. The same series of observations is now used to show the effect on the ratio (observed wind)/(geostrophic wind), the curvature of the isobars being neglected for the present. For a given gradient the ratio for the Bureau Central Météorologique increases as the lapse rate becomes greater, while for a given lapse rate the ratio increases as the gradient diminishes. Even at the top of the Eiffel Tower (300 m.) the velocity is not directly proportional to the gradient. The figures for the Bureau Central indicate a relation of the form $\log V = \log a + b \log V_G$, where V is the observed wind and V_G the geostrophic wind, *a* and *b* being numbers < 1 which are constant for a given lapse rate, but which increase as the lapse rate becomes greater. A relation of the same form would probably hold at other levels, *a* and *b*, for a given lapse rate, tending towards unity with increasing height and becoming unity at the level where the theoretical wind is realised. This level varies and is sometimes above and sometimes below 300 m. so that it is not surprising that the Eiffel Tower figures do not yield a simple relation of the above form. M. A. G.

975. *Use of Cirrus in Forecasting.* **G. Reboul** and **L. Dunoyer.** (Comptes Rendus, 170. pp. 744–747, March 22, 1920.)—Certain rules for the use of cirrus in forecasting weather are tested by the examination of synoptic charts in conjunction with hourly observations of cirrus made at a well-exposed station. A coefficient is assigned to each rule to measure the degree of success likely to be obtained by its application. This coefficient is the ratio of the number of successful cases to the total number examined. The rules are :—(1) The appearance of cirrus at a point indicates a depression, more or less in the neighbourhood of this point. (2) The direction of motion of the cirrus indicates the direction in which the depression is situated. (3) The direction of motion of the cirrus indicates the direction in which the depression is moving. (4) Fast-moving cirrus indicates a fast-moving depression. (5) Abundant cirrus indicates that the depression is near the place of observation or that it is deep.—The examination is extended to summer and winter separately and also to cirrus from westerly and from easterly regions. The conclusion reached is that for practical use cirrus from the east must be excluded and application must not be made to those southern districts of France influenced by Mediterranean depressions. Rule (1) has the coefficients 0·92 for summer, 0·94 for winter, and 0·96 for cirrus from the west, while rule (2) has 0·84 for summer, 0·81 for winter, and 0·91 for cirrus from the west. For the remaining rules, which would be the most useful in forecasting, the coefficients are unfortunately smaller, but a knowledge of the value appropriate to each rule enables an estimate to be made of the probability of success of a forecast based on it. M. A. G.

976. *Temperature at High Levels in the Atmosphere.* **V. Bjerknes.** (Comptes Rendus, 170. pp. 747–750, March 22, 1920.)—It is first shown that the increasing thickness of the troposphere equatorwards is consistent with the observed smallness of the movements relative to the earth in the stratosphere and the predominant westerly winds in the higher levels of the troposphere. The latter have been shown to be consistent with observed horizontal temperature gradients in a previous paper [see Abs. 817 (1920)]. Treating the earth and atmosphere, as before, as a symmetrical rotating system, the differential equation $dz/dx = - X/Y + x(\varrho_2\omega_2^2 - \varrho_1\omega_1^2)/Y(\varrho_2 - \varrho_1)$ represents the surface of discontinuity separating two layers of air in the upper of which the density is ϱ_1 and the angular velocity ω_1, and in the lower ϱ_2 and ω_2. Comparing this equation with that of " isobaric " surfaces given previously, it is seen that if $\omega_2 = \omega_1$ the surface of discontinuity coincides with an isobaric surface, while if $\omega_2 > \omega_1$ it may be likened to an ellipsoid more eccentric or " flatter " than the isobaric surfaces of either layer, since $\varrho_2 > \varrho_1$. If $\omega_2 < \omega_1$ the surface of discontinuity is less flat than the isobaric surfaces and may even be elongated in the direction of the earth's axis. Applying this to the discontinuity between stratosphere and troposphere, observation shows that ω_1 differs little from Ω, the angular velocity of the earth, and $\omega_2 > \Omega$. Hence $\omega_2 > \omega_1$ and the surface of separation should be " flatter " than the isobaric surfaces near the top of the troposphere, which in turn were shown to be " flatter " than " level " surfaces in the first paper. It follows that the troposphere increases in thickness equatorwards in agreement with observation. Secondly, applying the considerations of the first paper to cyclones and anticyclones, considering only the component of the earth's rotation about a vertical axis through the centre of the system, it is shown that in the higher levels of a cyclone the temperature should be higher, and in an anticyclone lower, than the normal for those levels. The considerations of the first part of the present paper give this result in another form, namely : above a cyclone the surface of separation between stratosphere and troposphere is lowered and above an anticyclone raised, again in agreement with observation. These two papers bring out the intimate relation existing in the atmosphere between temperature and centrifugal force. M. A. G.

977. *Primitive Form of Atmospheric Ice.* **L. Besson.** (Comptes Rendus, 170. pp. 607–609, March 8, 1920.)—Haloes of radii different from those of common haloes have been observed and six are recognised. The author makes, from the observed radii, certain deductions as to the form of the ice crystals composing the clouds which produce the haloes. He describes an ice crystal of hexagonal form, with oblique faces as well as the lateral faces and hexagonal ends, which presents twelve different dihedral angles, other than those of 60° and 90°, each of which might act as a refracting prism. The radii of the haloes produced depend on the common inclination of the oblique faces to the hexagonal axis of the crystal. It is found that, assuming an inclination of 25°, some of the twelve angles are too large to permit the light to pass through, while the remainder produce haloes with radii which agree well with the observed radii of five of the six less common haloes. These five are those of Van Buijsen (observed radius 8° 40′), Rankin (17° 39′), Burney (19° 15′), Dutheil (24°), and Feuillée ((32°–35°). Some of these have been observed together and might thus be easily produced by a single form of crystal. An angle of 28° produces a result almost as good, but, from considerations set out in the paper, the author inclines to the value 25° 14′·4 as the probable inclination of the oblique faces in the primitive form of crystal of atmospheric ice. M. A. G.

978. *Solar Activity, Solar Radiation, Air Temperature and Terrestrial Magnetism in the Course of a Sun's Revolution.* **G. Angenheister.** (Terrest. Magn. 25. pp. 17–26, March, 1920.)—A relationship doubtless exists between solar activity, on the one hand, and solar radiation, air temperature, and terrestrial magnetism on the other. Abbot has studied it on the basis of the 11-year period and has found that increased solar activity is accompanied by increased solar radiation but diminished air temperature on the earth, the latter being explained by the occurrence of increased cirrus at these times. The present writer approaches the subject by considering a period of about 26¼ days, that of the sun's rotation, and choosing, as most suitable, those times when sun-spots are confined to a specially small area of the sun's surface. He finds that solar activity, solar radiation and terrestrial magnetism show a periodic variation of 26 to 27 days, but that the phases of the variation of solar radiation and terrestrial magnetism show no relation to the times of extreme solar activity as measured by spots and faculæ. The spots and faculæ can thus hardly be regarded as a direct cause of the variations of radiation and magnetism. M. A. G.

979. *Spectra of Nova Aquilæ No. 3. II. Transition to Nebular Spectrum.* **J. Lunt.** (Roy. Astron. Soc., M.N. 80. pp. 519–539, March, 1920.) [See Abs. 858 and 1013, (1919).]—This takes up the history of the star from June 12th. Transition stage, June 12th to 15th. Nebular stage commencing June 17th, though chief nebular line did not appear till June 27th. Measures are given of width of bands of $H\delta$, $H\gamma$, $H\beta$, N_2, and N_1, as well as the characteristic nebular band and nova band. The last-named includes the bands at λλ4604, 4634, 4640, 4650, and 4686, none of which is definitely assigned, except the 4686, but N is probably involved in the group. The nitrogen bands are also considered in detail. The dates covered in the paper are 1918 June 15th to October 4th, and a further paper is promised. W. W. B.

LIGHT.

980. *Model Illustrating Light-emission.* **V. E. Gehrcke.** (Phys. Zeits. 21. pp. 172–175, April 1, 1920.)—Reference is made to an ether model containing atoms arranged somewhat as in crystals. Employing this arrangement the author has previously demonstrated the production of line-spectra, and now develops the model to illustrate light-emission. [See also Abs. 1056 and 1057 (1914)]. A. B. W.

981. *Filters Transparent to Ultra-violet Light.* **A. Miethe** and **E. Stenger.** (Zeits. Wiss. Phot. 19. pp. 57–68, Oct., 1919.)—By means of a quartz spectrometer comparisons have been made under constant conditions between the transparency of various colouring matters in different concentrations and that of a silvered quartz mirror. For 1 : 1000–1 : 20,000 tartrazine solutions the max. transparency increases from 300–308 μμ in the strongest to 280–391 μμ in the weakest solution. For filter yellow in similar concentrations the corresponding wave-lengths are 296–308 μμ and 270–500 μμ respectively, and for Martin's yellow, 321–330 μμ and 296–374 μμ. For a 1 : 9000 nitrosodimethylaniline solution, the max. transparency lies at 299–365 μμ and increases but little on further dilution. With increasing dilution fluorescein increases in transparency down to 260 μμ. In a 1 : 1000 solution eosin is transparent for 368–390 μμ and in 1 : 10,000 for 271–470 μμ. For exposures increasing from 5 to 640 seconds, the transparency of the silvered quartz mirror rises from 308–330 to 302–388 μμ. This mirror is hence decidedly less suitable than the dyestuff filters. T. H. P.

982. *How to Increase the Photographic Power of Large Telescopes.* **H. Shapley.** (Nat. Acad. Sci., Proc. 6. pp. 127–130, March, 1920.)—After quoting certain investigations in which scale is less important than intensity, such as the limiting faintest magnitude in globular clusters, the author points out that the 100-in. reflector only shows stars fainter by one magnitude than does the 60-in. under certain conditions, and will not show nebulæ any brighter, and goes on to describe the device of inserting a short-focus lens in the converging beam at an appropriate distance in front of the photographic plate. He works out formulæ for the increase of brightness corresponding to the reduction of scale, with 25% allowance for loss of light by absorption, finding that a reduction to ⅓ scale gives two more magnitudes. It is found that the theoretical gain realised in practice, *e.g.*, a 3-minute exposure on M. 77 reduced ⅓, shows much fainter nebulosity than a 10-minute exposure without intensifier. W. W. B.

983. *Electrical Double Refraction in Colloids.* **C. Bergholm** and **Y. Björnståhl.** (Phys. Zeits. 21. pp. 137–141, March 15, 1920.)—In extension of the work of Diesselhorst and Freundlich [Abs. 1090 (1916)], who showed that V_2O_5 sols became double-refracting under the influence of an electric field, the authors describe measurements on the dependency of the phase difference and of the amplitude effect on the electric field in sols of V_2O_5 and gold. It has, indeed, been found that gold sols, which, according to Diesselhorst and Freundlich, must have particles exhibiting spherical symmetry, show double refraction in an electric field; silver sols also show this transverse electrical double-refraction.

With electrical double refraction in liquids, the phase difference, as is known, increases in proportion to the square of the strength of the field, but with V_2O_5 sols this double refraction increases more slowly and probably reaches a limiting value at a sufficiently high tension. The connection of the sign of the phase difference with the absorption observed in the case of electrical double refraction in liquids also appears to hold for that of colloids. With V_2O_5 sols the double refraction is positive, that is, it resembles that of a glass plate stretching in the direction of the lines of force. Gold absorbs the red rays very strongly, the gold sol being negatively double-refracting. The dispersion of the double refraction in gold and V_2O_5 sols is very great.

Both gold and V_2O_5 sols are dichroic, the amplitude of the light which has traversed the sols having different values parallel (a_1) and perpendicular (a_2) to the lines of force; for V_2O_5 sols, $\varrho = a_1 : a_2$ is less than 1, whilst for gold sols ϱ is greater than 1 when λ is less than 618 $\mu\mu$, and less than 1 when λ is above 618 $\mu\mu$. T. H. P.

984. *Gauss' Theory of Refraction for Oblique Pencils.* **M. Tscherning.** (K. Danske Vidensk. Selskab. 1. No. 15. pp. 1–40, 1919.)—An application of the Gaussian theory of refraction to the case of oblique pencils at single refracting surfaces and with infinitely thin lenses.

J. W. T. W.

985. *Compensation for Astigmatism in Optical Instruments.* **J. Carvallo.** (Comptes Rendus, 170. pp. 1109–1112, May 10, 1920.)—Describes a ready method for the measurement of astigmatism and its elimination in cases such as that of inexpensive objectives of 1 to 1·5 metres focal length. J. W. T. W.

986. *Antagonistic Phenomena with Different Radiations* (*Ultra-violet, Visible, Infra-red*). **J. L. Pech.** (Comptes Rendus, 170. pp. 1246–1248, May 25, 1920.)—The author describes experiments in which it is verified that certain effects obtained when ultra-violet light acts on a system in physico-chemical equilibrium, are less easily observed if the proportions of visible and infra-red rays acting simultaneously are increased.

A. B. W.

987. *Theory of Newton's Rings.* **J. Marshall.** (Roy. Soc. Edinburgh, Proc. 40. 1. pp. 51–55, 1919–1920.)—A mathematical treatment is given of the passage of light through three media, and the results obtained are applied to elucidate some points in the theory of Newton's rings. If the refractive indices of the three media be r_1, r_2, r_3 it is shown that when $r_1 \neq r_3$ and $r_1r_3 \neq r_2^2$ there will be no ring formation due to interference, although there may be rings due to straining of the media at the surfaces of contact. When $r_1r_3 = r_2^2$ and $4a_0r_2 \neq \lambda$, a_0 being the shortest distance between media 1 and 3, a system of interference rings with a bright spot at the centre is obtained, but in the case when $r_1r_3 = r_2^2$ and $4a_0r_2 = \lambda$ a system of interference rings is obtained with a dark spot at the centre. Brewster used air, soap solution, and diamond for

his three media, giving respectively $r_1 = 1$, $r_2 = 1\cdot475$, $r_3 = 2\cdot44$. r_1r_3 is in this case nearly equal to r_2^2, and this explains why Brewster obtained a bright spot at the centre. A. W.

988. *Pressure Variation of Wave-length of Lines in the Cyanogen Bands.* **A. Perot.** (Comptes Rendus, 170. pp. 988–990, April 26, 1920.)—The author has investigated the lines in the cyanogen bands with the object (1) of finding the effect of varying the conditions of emission, (2) of testing whether the lines are really unaffected by pressure, as hitherto thought. Measurements made on the bands at λ4197 and λ3883 using first a vacuum carbon arc and then an ordinary arc at atmospheric pressure appear to show a difference, which, since the other conditions (such as current, potential, etc.) were the same for both arcs, is probably due to pressure. The wave-lengths of the vacuum arc lines were greater than the corresponding ordinary arc lines, the mean value obtained for $d\lambda/\lambda$ being $1\cdot6 \times 10^{-6}$. A. W.

989. *Critical Study of Spectral Series.* V. *Monatomic Gases.* **W. M. Hicks.** (Roy. Soc., Phil. Trans. 220. pp. 335–468, May 19, 1920.)—The first part of this paper gives a *résumé* of some of the laws developed by the author in earlier papers [Abs. 1953 (1913), 217 and 1357 (1917), 1200 and 1507 (1919)]. The remainder of the paper gives a discussion of the spectra of Kr, X, A, Ne, and RaEm with special reference to the laws previously given, and with the object of obtaining some knowledge of the series relations in the spectra of the above gases. A. W.

990. *On the Fine Structure of X-ray Spectra.* **M. de Broglie.** (Comptes Rendus, 170. pp. 1245–1246, May 25, 1920.)—It is well known when considering X-ray spectra that the peculiarities observed in the case of a particular element have a general interest, since the spectra of all the elements are somewhat similar in type. Theories recently advanced, as for example that due to Sommerfeld, give an interpretation of the differences of frequency between the rays in the same spectrum and predict a "fine" structure for certain rays. By means of a high resolving power the author has shown that the ray of the K spectrum of tungsten was a doublet in which $\Delta\lambda$ had a value 0·0007 Å.U. Tungsten has an atomic number 74, and it therefore becomes of interest to examine the same phenomenon in the case of an element whose atomic number is notably different, for example rhodium, of which the atomic number is 45. The author has in this case found the same doublet, $\Delta\lambda = 0\cdot0006$ Å.U. A. B. W.

991. *Calculation of Limiting Absorption Frequencies of the K and L Series for the Heavy Elements.* **L. de Broglie.** (Comptes Rendus, 170. pp. 585–587, March 8, 1920.)—The author refers to the theories of Bohr and Végard relating to this question. Tables of comparison are given in which the limiting absorption frequencies in the K and L_1 series of the heavy elements have been calculated from the formula of Bohr and Végard, and compared with the observations made by Végard, Siegbahn, and de Broglie.

For the K series both Bohr's and Végard's formulæ are in good agreement with observation. In the case of the L series, however, Bohr's values are much too high, whilst Végard's are in close agreement with observation. A. B. W.

992. *Statistical Method for Studying X- and Radio-active Radiations, and its Application to some γ-ray Problems.* **A. F. Kovarik.** (Nat. Acad. Sci., Proc. 6. pp. 105–107, March, 1920.) — The author refers to his modifications of the Rutherford-Geiger method of counting α- and β-particles. The method now used counts the impulses either acoustically (using valve amplifiers and telephones) or by automatically recording on paper. Using his modified method [for which see previous abstracts, Nos. 332 (1916), 59 (1917), 911, (1919)], the author has examined several important problems pertaining to the nature of γ-rays and X-rays, and also questions bearing on energy absorption and emission by an atom. The results so far obtained indicate that 7×10^{10} γ-ray pulses are emitted from radium B and C per sec. per gm. of radium. This result is higher than that obtained by Lawson and Hess [Abs. 113 (1920)], namely $2 \cdot 92 \times 10^{10}$.
A. B. W.

993. *New Method for X-ray Crystallography of Pulverised Substances.* **H. Bohlin.** (Ann. d. Physik, 61. 5. pp. 421–439, March 3, 1920.)—The method now described is essentially a development of that originated by Debye and Scherrer [see Abs. 1140 (1917)]. In the latter method a beam of X-rays is directed on a cylindrical pencil of the pulverised material, the reflected X-rays falling on a cylindrical photographic film concentric with the pencil. Debye's method is open to the objection that the sharpness of the spectral lines obtained is dependent to a marked degree on the width of the slit through which the primary X-ray beam passes.

In the method developed by the authors this difficulty is overcome in a very simple manner. The pulverised substance under examination is compressed to form a concave cylindrical surface, which is exposed to a divergent beam of X-rays, the beam diverging from a line on another part of the cylindrical surface which passes over the face of the crystalline powder. With this arrangement the reflected beams from the crystals come to a focus at the cylindrical surface, a photographic film being suitably disposed to receive them. The spectral lines obtained in this manner are remarkably sharp. It is shown that the sharpness and position of the lines is independent of the width of the slit or the penetrating power of the radiation.

By the method described an examination has been made of the "space lattices" of Al, Th, Ni, and Mg. Reproductions of actual photographs are given in illustration. A. B. W.

994. *Mass-Spectra of Chemical Elements.* **F. W. Aston.** (Phil. Mag. 39. pp. 611–625, May, 1920.)—The positive-ray spectrograph used by the author is described in detail and its technique explained. The spectrograph is capable of giving a focused mass-spectrum. The results of a provisional analysis of eleven chemical elements, H, He, C, N, O, Ne, Cl, A, Kr, X, and Hg, are given, showing that of these only the first five are "pure," the others being apparently composed of various numbers of isotopic constituents, krypton containing no less than six. With the exception of those due to H_1, H_2, and H_3, all masses measured, allowing for multiple charges, are exactly whole numbers within the error of experiment (O = 16). The lines due to hydrogen indicate that the mass

of the atom of this element is greater than unity on this scale, and in good agreement with the chemical value 1·008. Reasons for this are suggested.

Preliminary accounts of some of the work now dealt with have previously been given [Abs. 213, 265, and 721 (1920)]. A. W.

RADIO-ACTIVITY.

995. *Concentration of Radium and Mesothorium by Fractional Crystallisation.* **J. L. Nierman.** (J. Phys. Chem. 24. pp. 192–200, March, 1920.)—The crystallisation factor of mesothorium and radium in bromide solutions was found to be independent of the concentration of hydrobromic acid. A determination was made of the crystallisation factors corresponding to different percentages of cystals separating. For concentrations of mesothorium up to 2 mgm. per gm. of salt, the crystallisation factor remains constant. The separation of mesothorium and radium from barium can be conducted advantageously in neutral or dilute acid solutions of the bromides. A. B. W.

996. *Passage of Alpha and Beta Particles through the Earth's Atmosphere.* **C. Störmer.** (Comptes Rendus, 170. pp. 742–744, March 22, 1920.)—The author shows how Végard's investigation [Nordlichtsuntersuchungen, Videnskabsselskabets Skrifter, 1916, Christiania] of the diminution of speed of such particles on the supposition that the paths are rectilinear, can be extended to the consideration of the actual paths. When these paths and the speed variations of the particles are determined, the ionisation and luminosity at any point can be determined as effected by Végard on the assumption of rectilinearity, and the results compared with photographs of auroræ. G. W. DE T.

997. *Observations on the Radio-active Decay of Atomic Nuclei.* **H. T. Wolff.** (Phys. Zeits. 21. pp. 175–178, April 1, 1920.)—The author refers to a paper by Lindemann [Abs. 503 (1920)] in which certain interesting deductions are made from the Geiger-Nuttall law relating to the range of α-particles from and the decay constant of radio-active substances, namely: $\log \lambda = A + B \log R$, and to the relation $v = k\sqrt[3]{R}$ connecting velocity and range of α-particles. Combining these relations, we obtain $\lambda = v^{3B} \times$ const., a simple relationship between the decay constant λ and the velocity v of emission of α-particles.

The author works out the value of B for the members of the Th, Ra, and Ac series, and makes interesting deductions relating to the atom nucleus from which the α-particles originated. A. B. W.

HEAT.

998. *Gold-Point and Palladium-Point Relation.* **E. P. Hyde** and **W. E. Forsythe.** (Frank. Inst., J. 189. pp. 664–665, May, 1920, Astrophys. J. 51. pp. 244–251, May, 1920. Abstract.)—Describes a continuation of previous work on this subject [see Abs. 1643 (1916)], using several different black-body furnaces and both disappearing-filament and spectral pyrometers. The values for the palladium point, calculated from the value of 1336° K. for the gold-point and from $c_2 = 14{,}350\,\mu$ deg. were 1828·6° K. and 1828·3° K. for the two pyrometers, so that the value 1828° K. has been adopted as the palladium point in the Nela Laboratory.
J. W. T. W.

999. *The Quenching Behaviour of Liquids.* **N. B. Pilling.** (Phys. Rev. 14. pp. 222–227, Sept., 1919.)—Study of the mechanism of heat-transfer from a red-hot metal to the liquid in which it is quenched shows that cooling takes place in three distinct steps: (1) slow cooling by the formation and persistence of an enveloping sheath of vapour the thickness of which is, within certain limits, proportional to the initial liquid temperature; (2) rapid cooling owing to disappearance of the vapour sheath and the removal of heat by vaporisation of the liquid aided by local convection; and (3) slow cooling to temperatures below the boiling-point of the liquid, brought about by thermal conduction through the liquid. Analysis of cooling curves obtained by means of a string galvanometer shows that in each stage the cooling follows a simple exponential law of the form $\theta = Ac^{-Ct} + \theta_0$, where C is a constant which may be split up into c pertaining to the material and dimensions of the cooling mass) and h (relating to the properties of the active cooling agent). F. C. A. H. L.

SOUND.

1000. *The Theory of Receivers for Sound in Water.* **H. A. Wilson.** (Phys. Rev. 15. pp. 178–205, March, 1920.)—*Sound receivers in water; mathematical theory.* (1) *Single receivers.*—After proving that a receiver must have a small volume to be efficient, the author considers in detail the case of a small spherical receiver connected to the ear by a cylindrical tube. Its resonance frequency is independent of the size of the tube and depends only on the elasticity of the receiver and its effective mass. The sharpness of resonance, however, is greater for larger tubes and for smaller surfaces. The energy transmitted for a given patch is a maximum for a certain tube size; and while it is independent of the surface at the resonance frequency, for lower pitches the intensity increases with the surface. It is shown that a resonating receiver with a properly chosen tube may concentrate into the tube energy from an area about 850 times the cross section of the tube. The theory agrees with experimental facts and leads to practical suggestions for the design of efficient receivers. (2) *Two receivers as used for direction finding.*—A pair of receivers mounted on a horizontal rod which may be rotated about a vertical axis is an efficient device for getting the direction of a source of sound since it makes use of the binaural effect. The equations for the energy in each tube and for the difference in phase are derived. Unless the separation is very small, the conditions for correct direction finding are always satisfied. The best distance apart is half the wave-length in water for the resonance frequency of the receivers. (3) *Multiple receivers.*—If n receivers are each connected by a tube with a cross section a to a tube whose cross section is na, and if the lengths are such that all the sounds meet in phase, practically all the sound may be concentrated in a single tube. Equations are derived for the case of symmetrically arranged receivers, all equidistant from the source of sound. Except at the resonance frequency, the multiple receivers should be, in practice, more sensitive than any single receiver. (4) *Lines of receivers.*—By a special compensating device the sound from such a set may be concentrated in a single tube. Equations are derived for the energy transmitted in this case. (5) *Receivers distributed over large areas.*—With flexible diaphragms, complete transmission may be secured if the ratio of the tube section to the diaphragm area is properly chosen. With stiff diaphragms this is approximately true only for the resonance frequency of the receivers. Finally, the conditions for complete transmission for a given frequency are determined for the case of small receivers mounted in a plane in front of a totally reflecting parallel surface. AUTHOR.

1001. *Acoustical Experiments.* **H. Kayser.** (Phys. Zeits. 21. p. 11, Jan. 1, 1920.)—Gives an account of two lecture experiments. The first makes a difference tone plainly audible to a class by use of an open glass pipe and one closed by an adjustable stopper. Thus if the lower of the two tones is slightly sharpened the difference tone sinks very considerably. The second shows the four alternating zones of wave motions in opposite phases round a tuning-fork by rotation of the fork (taken from its resonance box) over a resonance tube set to reinforce its tone. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS AND ATMOSPHERIC ELECTRICITY.

1002. *On the Potentials of Incomplete Ellipsoids.* **Nikhilranjan Sen.** (Calcutta Math. Soc., Bull. 10. No. 3. pp. 157–178, 1918–19.)—Grube indicated a method of obtaining the potential of an incomplete ellipsoid. The author, adopting this method, gives expressions for the potentials of heterogeneous incomplete ellipsoids and elliptic discs. He also, incidentally, finds the potentials of ellipsoids with certain discontinuous distributions of mass. The results given have all been obtained by the use of discontinuous factors, a method used by Dirichlet in the determination of the potential of a uniform ellipsoid. A. R.

1003. *Inferences from the Hypothesis of Dual Electric Conduction : the Thomson-Effect.* **E. H. Hall.** (Nat. Acad. Sci., Proc. 6. pp. 139–154, March, 1920.)—Two papers read by the author before the National Academy of Science in April 1919, and which have not yet been published, dealt with the effect of pressure on electrical resistance, the Peltier-effect, and thermal conduction in metals from the standpoint of dual electric conduction [see also Abs. 704, 868 (1918)]. It was pointed out that increase of pressure by bringing the atoms and metal ions nearer together would increase the conductivity (k_a) of the associated electrons and decrease the free electron conductivity (k_f). If k_f/k_a is small for a metal, increase of pressure will increase the total conductivity, whereas for a large value of this ratio the conductivity would be diminished by increase of pressure. Sb and Bi have small values for k and probably large values for k_f/k_a. Of 20 metals examined by Bridgman, Sb and Bi were the only two to show decrease of electrical conductivity on increase of pressure. If a current passes from a metal A to a metal B ionisation occurs at the junction if k_f/k_a is greater for B than for A and reassociation when the current is reversed. This would correspond to heat absorption in the former case and evolution in the latter, and would play a part in accounting for the Peltier heat. Before proceeding with the further application of this dual theory to thermal conduction it is necessary to interpret the Thomson-effect from this point of view. The sum of the energy-changes for the free and associated electrons during the passage of $1/e$ electrons from an isothermal at T, to one at T + dT gives $\sigma \,.\, dT$, and if it is assumed that the mechanical tendency is towards equality of pressure the author shows that

$$\sigma = \frac{k_f}{k}\frac{3}{2}\frac{R}{e} - \frac{k_f}{k}\frac{RT}{ne}\frac{dn}{dT} + \frac{\lambda'}{e}\frac{d(k_f/k)}{dT},$$

where n = number of free electrons per cm.^{3} of metal, and λ' = latent heat of ionisation per electron. If the mechanical tendency is towards thermal effusion equilibrium the factor 2 is substituted for $\frac{3}{2}$ in the first term of the expression for σ.

The author then assumes $n = zT^q$ and $k_f/k = C + C_1t + C_2t^2$, where z, q, C, C_1 and C_2 are constants and t is the temperature on the centigrade scale.

The expression is then thrown into the form $\sigma = K + (K_1 + K_2t)T$, where K, K_1 and K_2 are constants. Bridgman expressed his experimental results for σ in the form $\sigma = (A + Bt)T$, B being zero in many metals.

The value of K in the author's theory is not zero, but it is probably so small as to be negligible. K_1 and K_2 are then identical with A and B of Bridgman's equation. His experimental data are then used to evaluate k_f/k at 0° and 100° C., the ionising potential, and q. The numerical values obtained are discussed and data from the effects of pressure on electrical resistance give evidence in favour of the author's theory. L. L.

1004. *Equal Parallel Cylindrical Conductors in Electrical Problems.* **F. J. W. Whipple.** (Roy. Soc., Proc. 96. pp. 465–475, Feb. 3, 1920.)—The author gives a complete mathematical solution of the problem discussed by Russell [Abs.778 (1919)] by the method of conjugate functions. For the most part, the results are given in forms, convenient for numerical calculation. The investigation is confined to the case when the two cylinders are of the same size. In this case ordinary Jacobian elliptic functions suffice. In general, however, theta functions are required and the algebra is heavy. Tables are given from which the potential and capacity coefficients of the cylinders can be readily computed. Tables are also given for the surface densities on the cylinders and the resultant force between them. A. R.

1005. *Effect on an Insulated Wire of the Electricity Carried by Rain.* **A. Baldit.** (Comptes Rendus, 169. pp. 910–912, Nov. 17, 1919. Rev. Gén. d'Él. 6. pp. 811–812, Dec. 6, 1919.)—States some preliminary results, mainly qualitative, of an investigation of the effect of precipitation carrying an electric charge on an insulated wire, 100 m. long, stretched horizontally 8 m. above the ground. An electroscope, capable of measuring directly differences of potential of 900 volts, is attached to the wire, while another gives the sign of the charge accumulated on the wire. The charge carried by the rain is determined by an electrometer. Of 940 observations 68% show charges on the wire and on the rain opposite in sign, and 32% the same sign. The charge on the wire may change sign without that on the rain doing so, but often the former event precedes or accompanies the latter. The charge on the wire or its potential is in general greater, the greater the charge on the rain. During thunder showers the potential of the wire frequently exceeds 1000 volts. Measurements of the earth's field show that its sign is mostly the same as that of the charge on the wire and its value near that which might be deduced from the potential of the wire. It is concluded that the disturbances observed in aerial wires during thunder showers proceed rather from the earth's field than from the charges carried to the wires by the rain. M. A. G.

1006. *Ionisation Equilibrium in the Atmosphere.* **E. v. Schweidler.** (Akad. Wiss. Wien, Ber. 127. 2a. pp. 953–967, 1918.)—A discussion of earlier methods for determining the coefficient of recombination for ions in free air leads to the conclusion that the results so obtained were considerably in error, being much too small. A theoretical treatment of atmospheric ionisation leads to the same conclusion. Measurements by a new method show that the value of the recombination coefficient is about 29×10^{-6} instead of $1{\cdot}6 \times 10^{-6}$ for purified air and 2 to 4×10^{-6} for ordinary air as obtained previously. Meteorological conditions, such as winds or mist, have a marked effect on the results obtained. A. W.

DISCHARGE AND OSCILLATIONS.

1007. *Period and Decrement of an Oscillatory Circuit with a Short-circuited Secondary.* **I. Jones.** (Phil. Mag. 39. pp. 553–565, May, 1920.)—A primary circuit, with self-inductance L_1, capacity C_1, and resistance R_1, is coupled with a closed secondary coil having self-inductance L_2 and resistance R_2, the mutual inductance of the two coils being M. It is assumed that the capacity of the secondary is negligible, and the resistance R_2 may be varied by altering the thickness or the specific resistance of the secondary wire. Calculation shows that the general effect upon the damping of the oscillations caused by increasing R_2/L_2, with the coupling kept constant, is an almost linear increase. With a low coupling such as 0·5, the damping increases rather slowly with increase of R_2/L_2, whilst for greater values of the coupling the increase is more rapid and also more nearly uniform, the curve for $k^2 = 0{\cdot}95$ being almost exactly a straight line. The effect of the variation of the coupling upon the decrement, R_2/L_2 being kept constant, is shown graphically. The decrement increases with the coupling, more and more rapidly the closer the coupling. Corresponding graphs are given for the effects on the frequency. With any given coupling the frequency diminishes as the ratio R_2/L_2 increases, the diminution being more rapid the greater the value of the coupling. With a constant value of R_2/L_2, the effect of increasing the coupling is to increase the frequency, the rate of increase being greater for the smaller values of R_2/L_2. For certain values of k^2 and R_2/L_2 the corresponding values of the frequency become imaginary, which means that no oscillations are produced at these values of k^2 and R_2/L_2. It is shown that there is a limiting value of k^2, below which there are real oscillations for all values of R_2/L_2, and above which there is a finite range of values of R_2/L_2, over which no real oscillations are produced. The limiting value for k^2 is 0·889. Curves are given to illustrate this effect. A. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1008. *Ageing in Standard Weston Cells.* **A. N. Shaw** and **H. E. Reilley.** (Roy. Soc. Canada, Trans. Sect. 3. pp. 171–176, 1919.)—The effects of ageing on some Weston normal cells have been examined, and it has been found that the constancy and accuracy of these cells do not suffer if they are made to a much less rigid specification than is usual. Ten cells made at the McGill University in 1909 have apparently fallen by 72, 70, 32, 52, 45, 38, 50, 103, 117, and 88 microvolts respectively, and three cells from the National Physical Laboratory have in 7 years fallen by 47, 5, and 5 microvolts respectively. The authors recommend that the mercurous sulphate should if possible be obtained from a "standards" laboratory; they find that recrystallisation of the cadmium sulphate is unnecessary and that commercially pure cadmium is satisfactory. F. E. S.

1009. *Temperature Coefficient of Manganin.* (El. World, 75, p. 941, April 24, 1920.)—E. B. Rosa, of the Bureau of Standards, reports that samples of manganin tested in the Bureau between 15° and 30° C. have in general shown a temperature coefficient varying between 4 and 20 parts in a million per degree. The mean temperature coefficient over the range 18° to 24° C. is given in the following table, which also gives the analysis of the 6 samples reported on.

DATA ON THE TEMPERATURE COEFFICIENT OF MANGANIN.

Sample.	Analysis of Material.				Temperature Coefficient 18°–24° C.	Resistivity in Microhms-cm.
	Cu.	Mn.	Ni.	Fe.		
1	88·02	9·93	1·74	0·24	1·2 × 10^{-5}	34·2 × 10^{-6}
2	87·24	10·26	1·77	0·52	1·5 × 10^{-5}	37·4 × 10^{-6}
3	88·20	8·84	1·78	0·93	0·33 × 10^{-5}	55·6 × 10^{-6}
4	83·60	12·03	3·41	1·04	0·22 × 10^{-5}	47·8 × 10^{-6}
5	84·72	12·83	2·08	0·73	0·38 × 10^{-5}	50·8 × 10^{-6}
6	84·07	12·98	2·60	0·82	0·57 × 10^{-5}	51·1 × 10^{-6}

It is observed that the percentage of manganin, between the limits used, affects the resistivity of the wire, but has no effect on the temperature coefficient of resistance. The presence of iron, on the other hand, affects the temperature coefficient to a considerable degree.

F. E. S.

1010. *Piezo-optic Effect in Topaz.* **R. Eppendahl.** (Ann. d. Physik, 61. 7. pp. 591–632, April 15, 1920. Dissertation, Göttingen.)—Describes an investigation of the piezo-optic properties of various specimens of topaz. The chief interest of the paper lies in the numerous tables of results and in the theory to which the results are referred. A. W.

ALTERNATING CURRENTS AND MAGNETISM.

1011. *Magnetic Properties of Iron-Nickel Alloys.* **T. D. Yensen.** (Am. I. E. E., J. 39. pp. 396–405, April, 1920. El. World, 75. pp. 774–777, April 3, 1920.)—Alloys were prepared which contained 0–100% nickel by melting electrolytic iron and electrolytic nickel in magnesia crucibles in an Arsem type vacuum furnace. Pure Fe-Ni alloys do not forge well at ordinary temperatures, and it was necessary in some cases to machine rings from the ingots. The magnetic testing of rods was done by the Burrows compensated double bar and yoke method; the rings were tested by the ordinary two-winding method. The results show that the saturation intensity, I_s, decreases slightly from pure iron to 20% nickel. Between 20 and 30 per cent. I_s decreases to one-tenth of the max. value, increases rapidly beyond 30%, reaches a maximum for 50%, and finally decreases gradually towards 100% nickel, the value for pure Ni being slightly more than one-fourth that for pure iron. For B = 10,000, the hysteresis loss rises with Ni content to 50,000 ergs for the 25% alloy; between 30 and 70% Ni it is as low as for pure iron, and for pure Ni it is 20,000 ergs. The retentivity decreases with increase of nickel to a minimum of 200 for the 30% alloy. There is a maximum at about 53%

nickel. The values for electrical resistance agree with those given by Burgess and Honda, and there is a maximum for 30% nickel. The results indicate the existence of an iron-nickel compound corresponding to 30% nickel. On changing from room temperature to − 80° C., and then to − 180° C., the saturation intensity of the 30% Ni alloy changed from 2700 to 14,600 and 17,800 respectively; also the electrical resistance under the same conditions changed from 82 to 38 and 32. There is no apparent change in the microstructure accompanying these transformations. [See also Abs. 1511 (1913).] G. E. A.

1012. *Influence of Molecular Constitution and Temperature on Magnetic Susceptibility.* IV. **A. E. Oxley.** (Roy. Soc., Phil. Trans. 220. pp. 247–289, April 9, 1920.)—A continuation of previous work [see Abs. 495 (1915)]. The hypothesis of the presence of a local molecular field in all media is applied to interpret the ultimate tensile strength of crystalline and vitreous media. The internal stress due to the field is shown to be of the order 2×10^9 dynes/cm.^{2}, which is also approximately the mean value of the ultimate tensile strengths of crystalline and vitreous media. As a consequence, the energy per unit volume is 2×10^9 ergs, and this should be a measure of the latent heat of fusion per cm.^{3} This test is found to accord with experimental values to the right order. Further, any change of internal pressure will be accompanied by a change of volume, and the change of volume on crystallisation is interpreted as a magnetostriction effect caused by the local molecular field. Tyndall's experiments with crystals in a magnetic field lead to results which show that the forces responsible for crystalline symmetry are very probably of a magnetic nature. The magnetic forces are partly due to the boundary or valency electrons whose orbits are controlled by the atomic nuclei. The smallness of the nucleus, as disclosed by recent work, suggests that the magnetic forces are also in part responsible for chemical combination. The author has already shown that the magneton may be a constituent of the diamagnetic hydrogen molecule. This idea may be extended to carbon and the hydrocarbons; the results are not so convincing, however, when extended to other elements. It is hoped to extend the applications of the hypothesis to spectral series and optical activity. G. E. A.

1013. *Induction Inclinometer.* **W. Uljanin.** (Terrest. Magn. 24. pp. 113–117, Sept., 1919.)—Describes in detail and gives theory relative to an improved method of determining the inclination of the earth's magnetic field to the horizontal, using Wild's induction inclinometer. A. W.

1014. *Determination of Horizontal Component of Earth's Magnetic Field.* **W. Uljanin.** (Terrest. Magn. 24. pp. 118–131, Sept., 1919.)—The method here described is similar in principle to that of Schuster [Abs. 1902 (1914)]. A full account is given of improvements effected and of measurements made with the apparatus. [See Abs. 1621 (1914).] A. W.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1015. *Triatomic Hydrogen.* **G. L. Wendt** and **R. S. Landauer.** (Am. Chem. Soc., J. 42. pp. 930–946, May, 1920.)—A reactive modification of hydrogen has been obtained by various methods, all dependent on gaseous ionisation: by the α-rays from radium emanation, by electrical discharge under reduced pressure, and by the high-potential corona at atmospheric pressure; attempts to produce activation by means of Schumann light-rays proved unsuccessful. This active hydrogen reduces sulphur, arsenic, phosphorus, mercury, nitrogen, and both acid and neutral permanganate. It is condensed or destroyed at the temperature of liquid air, and it passes readily through glass wool. It is unstable and reverts to the ordinary form in about a minute, but it is not less stable at atmospheric than at low pressure.

The activity is not due to gaseous ions, and the properties of the active gas are quite different from those of Langmuir's atomic hydrogen. The formation of a polyatomic molecule is indicated by the contraction of the hydrogen when ionised. Positive-ray analysis at very low pressures shows a large proportion of triatomic molecules, which are undoubtedly the ones responsible for the chemical activity. All the properties of the gas point to its ozonic form, and the name "hyzone" is suggested. The existence of H_3 is applied to the explanation of several phenomena previously observed. The calculations of Bohr on the basis of Rutherford's atom furnish the only valency hypothesis which accounts satisfactorily for its existence. Stable hydrogen molecules perhaps undergo dissociation into free atoms when an electron is removed during the process of ionisation, these atoms then attaching themselves to neighbouring neutral molecules to form triatomic systems. T. H. P.

1016. *Annealing Temperature of Glass.* **M. So.** (Phys. Math. Soc. Japan, Proc. 2. pp. 113–116, May, 1920.)—The paper describes the method adopted by the author for determining the relation between the annealing temperature and annealing time for borosilicate glass, soda glass, lead glass, and soda-lead glass. It was found that (i) the higher the softening temperature of a glass, the higher is its annealing temperature; (2) the annealing time of a glass logarithmically decreases with the rise of annealing temperature. [See also Abs. 1260 (1918).] J. W. T. W.

1017. *Microstructure of Iron and Mild Steel at High Temperatures.* **H. S. Rawdon** and **H. Scott.** (Am. Inst. Mining Eng., Bull. No. 128. [20 pp.] Feb., 1920. Bureau of Standards, Bull. 15. pp. 519–528 [Sci. Papers No. 356], 1920.)—The "heat-relief" or "vacuum etching" method of revealing the microscopic structure of metals has been investigated by heating specimens of re-melted electrolytic iron and 0·18% carbon steel *in vacuo* at temperatures above A3, between A2 and A3, and below A1. In specimens heated above A3 two distinct patterns are formed: (1) a pattern similar to that developed by etching at ordinary temperatures, superimposed on (2) a network built up largely of straight lines and showing distinct signs of twinning. This network delineates the structure of γ iron. Specimens heated below A3 show only the ordinary structure indicating that no characteristic crystal form corresponds to the β range, thus confirming the work of Rosenhain and Humfrey. The structure developed is due to a slight roughening of the surface brought about by volatilisation and a slight buckling caused by volume-changes during the transformation. Quite an appreciable change in the composition of the surface layers of steel occurs on heating *in vacuo* due to the volatilisation of the carbide. The surface of mild steel becomes carbonless, while in hypereutectoid steels the cementite grain envelopes gradually diminish in thickness and disappear at some distance below the surface. No appreciable change in surface composition occurs until the carbide has passed into solid solution, *i.e.*, just above the A1 transformation point. The surface volatilisation of iron is very slight, but is greater at the crystal boundaries than across the face of the crystal. F. C. A. H. L.

1018. *Changes in Steel during the Critical Interval $Ac_1 - Ac_3$.* **J. G. Ayers, Jr.** (Am. Soc. for Testing Materials. Rev. de Mét. 16E. pp. 374–376, Nov.–Dec., 1919.)—A bar of steel 100 mm. in length and containing 0·5% carbon has been heated to above the critical range at one end and quenched. By subsequent polishing and etching and micrographic examination of the whole length, the continuous changes of the pearlite to martensite and the growth of the martensitic grains at the expense of the ferrite have been observed. F. C. A. H. L.

1019. *Radio-metallography. A General Discussion.* (Faraday Soc., Trans. 15. pp. 1–39, 40–88 and Appendix, pp. 3–64, Feb., 1920.)—After introductory remarks by **R. A. Hadfield** papers were read, on "The Examination of Materials by X-rays," by **W. H. Bragg**; "The Detection of Haircracks in Steel by X-rays," by **C. F. Jenkin**. Numerous further papers were contributed; these have all been abstracted separately under their respective titles. L. H. W.

1020. *Nature of the Heat Production in a System of Platinum Black, Alcohol, and Air.* **L. B. Loeb.** (Nat. Acad. Sci., Proc. 6. pp. 107–110, March, 1920.)—The incandescence occurring when platinum black is introduced into air saturated with ethyl or methyl alcohol vapour has been explained in two ways: (1) Owing to the enormous surface and low thermal conductivity of platinum black the adsorption of the alcohol vapour liberates sufficient heat to raise the temperature of the platinum considerably, the consequent acceleration of the rate of oxidation of the alcohol vapour in the neighbourhood of the platinum causing further rise in temperature to incandescence. (2) The heat produced is due primarily to oxidation of the alcohol at the surface of the platinum, adsorption contributing relatively little heat; the surface of the platinum is, however, supposed to exert a "catalytic" action in the alcohol vapour and oxygen so as to cause very great increase in the velocity of the reaction.

In order to decide between these two explanations, the author has made use of a thermo-couple covered with platinum black to determine the relative rise in temperature of the platinum black due to adsorption of alcohol vapour in presence and in absence of air. The results obtained show clearly that the heat generated by adsorption is negligible compared with that produced by oxidation and would not be capable of increasing appreciably the velocity of reaction. Hence adsorption is not the initiator of the reactions which heat the platinum to incandescence, and the rise of temperature must be explained on the basis of an increased rate of oxidation of the alcohol at the surface of the platinum ("catalytic" action) coupled with the physical properties of the platinum black.

T. H. P.

1021. *Supersaturation and Crystal Size.* **W. D. Bancroft.** (J. Phys. Chem. 24. pp. 100–107, Feb., 1920.)—A theoretical paper in which the theory put forward by v. Weimarn in connection with the relationship between the degree of supersaturation and the size of crystals (*Grundzüge der Dispersoidchemie*, 1911, p. 39) is discussed and shown to be inadequate, because it does not take account of the number of nuclei formed. It is shown that, with vigorous stirring and increasing supersaturation, a substance, which normally is precipitated anhydrous, may be obtained as a colloidal solution, a curdy precipitate, fine crystals, coarse crystals, or a gelatinous precipitate. At higher temperatures precipitates are, as a rule, more coarsely crystalline than at lower temperatures. The theory of v. Weimarn applies to solutions which are not stirred. The conditions for forming large crystals are those in which the rate of crystallisation is so slow that branched crystals do not form. The effect of adsorption on the growth of crystals is not adequately covered by v. Weimarn's theory.

T. S. P.

1022. *Surface Tensions of Mixtures of Water and Alcohol.* **J. B. Firth.** (Chem. Soc. J., Trans., 117. pp. 268–271, March, 1920.)—With the object of arriving at a convenient method for determining small changes in concentration of the binary mixture, alcohol and water, the author has measured at 25° the surface tension by the drop-number method for such mixtures containing from 2 to 96·5% of water by volume [see Donnan and Barker, Abs. 269 (1912)]. A sudden fall in drop-number occurs at about 2% of water, further increase in the percentage of water up to 50 producing only a small change in drop-number; the latter, indeed, remains almost constant over the range 2–10% water. Beyond 50% of water the drop-number falls more rapidly. The curve connecting surface tension with concentration is hyperbolic as far as about 4% of water, the tension diminishing rapidly with subsequent diminution of water-content; the inflection in the curve corresponds almost exactly with the concentration, 4·4% of water, given by Young and Fortey for the mixture of minimal boiling-point.

The utility of the drop-number : concentration curve for analytical purposes varies with the range. Where the water content is more than 50% the curve yields moderately accurate results, but for lower concentrations the change in drop-number with change of concentration is not sufficiently marked to furnish trustworthy results. T. H. P.

1023. *Study of Amalgams.* **G. Mayr.** (N. Cimento, 19. pp. 116–128, March, 1920.)—The author gives a brief summary of previous work on the constitution of amalgams, and from the results of her own experiments, not described in detail, the following conclusions are drawn :—When the chemical constitution of an amalgam is known, determination of the e.m.f. of a concentration cell furnishes a means of deducing the ratio between the concentrations of the two amalgams forming the cell. During the passage of a current through an amalgam the metal dissolved in the mercury is transported towards the arode, that is, in the direction of the negative current. As regards such transport no appreciable distinction is evident (1) between metals, such as thallium, which give rise to compounds with the mercury, and those, such as zinc, which dissolve as such in the mercury, or (2) between metals, such as sodium and potassium, which increase the resistance of the mercury and those such as zinc which diminish the resistance. Thus, in contradiction to Lewis' view [compare Lewis, Adams, and Lanman, Abs. No. 265 (1916)], such transport of the metal does not appear to be related to the increase or decrease of the resistance of the mercury produced by dissolution of the metal. Increase in the resistance of mercury may depend on the specific resistance of mercurides formed by the dissolved metal. T. H. P.

1024. *Theory of the Heat of Reaction.* **F. Haber.** (Deutsch. Phys. Gesell, Verh. 21. pp. 750–768, Dec. 5, 1919.—Critical remarks on Born and Fajans' work [Abs. 162 and 272 (1920)]. As regards the energy of hydration, Born's figures refer to absolute zero, whilst the heats of solution were determined at ordinary temperatures. In the total energy calculations these errors cancel out, as Hildegard Miething's tables (dissertation, Berlin, 1918) show. But in the calculation of the energy components, Fajans neglects the phase-limit potential P, gas space/metal, which itself is the sum of two unknown terms. Haber hence suggests another deduction. On Born's view of electronic affinity [Abs. 641 (1920)] we can imagine a cyclic nucleus displacement in the NaCl-lattice; that, however, would not really confirm the view; moreover no value can be found for n the repulsion exponent) which would accord with the value 310 kg. cals. for the dissociation energy of the H atom. But we have to consider that the case of the solid crystal lattice and that of the gaseous HCl differ in so far also as the anion is equally attracted in all directions in the crystal, whilst it has its H-ion on one side only in the gas. A method of arriving at an agreement is outlined. It is suggested in this connection that, if the chlorine ion be a cube with 8 electrons and a sevenfold positive nucleus, and the sodium ion a similar cube (of different side) with ninefold positive nucleus, the displacement of the Cl-nucleus by the one-sided action of the H-ion would be analogous to the displacement (in the opposite sense) of the Na-nucleus by the valency electron. As regards the dissociation energy of salt vapours and the ionisation potential of metal kations, pure gas reactions (solid phases not participating) like $Cl + H = HCl$, $Cl + Na = NaCl$, $Cl + Li = LiCl$, etc., should have practically the same heat value. This question remains open as many thermal data are insufficiently known. With respect finally to lattice energy U and the ultra-violet frequency, U should (Born) be $= Nh\nu_e$. This holds approximately for NaCl and KCl, and as far as can be deduced from Rubens' observations (*Reststrahlen*) in the infra-red, also for other alkali and thallium compounds except LiF. H. B.

1025. *Photosynthesis and the Electronic Theory.* **H. H. Dixon** and **H. H. Poole.** (Roy. Dublin Soc., Proc. 16. pp. 63–77, March, 1920.)—The author's experiments are considered to show that those wave-lengths of light which are effective in photosynthesis are unable, to any appreciable extent, to expel electrons from the leaf-pigment complex, and hence cannot in this way produce ionisation, or bring about reactions external to the pigment. The action apparently occurs within the molecule of the chlorophyll itself. Possibly electrons are transferred from one atom to another, thus altering the linkage, and hence the chemical nature of the molecule, or its atomic groups. L. H. W.

1026. *The Modality of Reactions and Chemical Dynamism; Electrolysis and Spectroscopy.* **J. Meunier.** (Soc. Chim., Bull. [IV.] 28. pp. 49–68, Feb., 1919.)—The author wishes to establish the relations between physical and chemical phenomena. The chemical dynamism in electrolytic reactions varies in infinite modalities according to the nature of the constituents, and that holds also for flame spectra. A substance does not acquire the temperature of the flame; oxygen may cause both oxidisation and reduction, and the appearance of the spectrum does not characterise the particular element, but the reactions of this element with other elements present. H. B.

1027. *Relation of Voltage of Dry Cells to Hydrogen-ion Concentration.* **H. D. Holler** and **L. M. Ritchie.** (Bureau of Standards, Bull. 15. pp. 659–668 [Sci. Papers, No. 364] 1920.)—It is pointed out that according to Nernst's equation the potential of the manganese peroxide electrode should be a logarithmic function of the hydrogen-ion concentration. Experiments were therefore made on manganese peroxide electrodes, using various kinds of ore, and their potential was measured in ammonium chloride solution with various hydrogen-ion concentrations. It was found that the law held in the case of mixtures of graphite and some manganese ores, but that the potential of similar electrodes containing a chemically prepared oxide was independent of the hydrogen-ion concentration. The potential of the natural ores steadily decreased with time in acid solution and slowly increased in alkaline solutions. Slight variations in the hydrogen-ion concentrations of ammonium chloride and zinc chloride are sufficient to account for variations of several hundredths of a volt in the open-circuit voltages of dry cells containing the same ore. Part of the polarisation of a dry cell during discharge may be due to the layer of electrolyte on the surface of the electrode becoming impoverished in hydrogen ions. W. R. C.

1028. *Electro-deposition of Nickel on Aluminium and its Alloys.* **L. Guillet** and **M. Gasnier.** (Comptes Rendus, 170. pp. 1253–1256, May 25, 1920. Rev. de Mét. 17. pp. 351–359, May, 1920.)—The difficulty of obtaining an adherent electro-deposit of nickel on aluminium had formerly been partly overcome by a preliminary treatment of the Al surface with hydrochloric acid. A micrographic examination of the coated metal has shown that this action is due to the production, during the acid treatment, of fissures in the surface which assist in the adhesion of the deposited metal.

It is found that a more favourable effect is brought about by subjecting the metal to a sand-blast treatment and plating from an electrolyte consisting of a solution of nickel sulphate together with nickel ammonium sulphate.

Deposits of Ni up to a thickness of 0·01 mm. resist successfully mechanical tests consisting of rolling, bending, and burnishing the metal, while deposits of 0·04 mm. thickness do not withstand these tests. On the other hand, deposits of thicknesses below 0·04 mm. will not protect against the attack of heated sodium hydrate solution. By using finelydivided sand in the sand-blast treatment, a finer grained structure of the deposited Ni is obtained than when sand of coarser particles is used. A deposit which resists satisfactorily both the mechanical tests and corrosion with heated sodium hydrate solution is obtained by first coating the Al to a thickness of 0·006 mm. with nickel, by employing a current of 0·8 amp./dm.^{2} for $\frac{1}{2}$ an hour. A layer of copper—which will not adhere direct to the Al—is then deposited to a thickness of 0·02 mm. on the Ni surface and, after polishing the copper deposit, a second coating of Ni of 0·005 mm. thickness is finally superposed by employing a current density of 0·5 amp./dm.^{2}. Aluminium which has been coated in this manner can be firmly soldered. J. N. P.

1029. *Mobility of Electrolytic Ions.* **M. Born.** (Zeits. f. Physik, 1. 3. pp. 221–249, 1920.)—Assuming the dissolved molecules to be rigid spheres in a continuous liquid subject to internal friction, Einstein calculated the size of sugar molecules from Stokes' law, and R. Lorenz applied the same formula to the mobility of the much smaller ions. Two facts are apparently incompatible with these views: (1) Divalent ions have smaller average mobilities than monovalent ions, and the latter again smaller mobilities than neutral molecules, so that increase of the electric charge seems to diminish the mobility; (2) in the monatomic alkali-ions the mobility increases as the atomic volume increases, that is, *k* radii calculated from the mobilities are in the inverse order of the natural sequence; the smallest ion, lithium, would appear to have the strongest electric field and to drag more water molecules with it than the bigger ions. As regards hydration, there must be a certain adhesion of the water molecules to the ion, but the ion cannot much be enlarged by these means, since the decisive factor in the formula is the internal friction, not the external friction between the sphere and the water. If the water molecules be electric dipoles they will turn under the influence of the electric field, and the first layer of water molecules will adhere to the ions and further layers will be attracted. As the ions move, the internal friction will prevent the dipoles from taking up normal radial positions, and the turning moment will be the greater, the greater the charge and the smaller the radius. The problem is treated mathematically; it is mentioned that all dipole-liquids possess a certain electrolytic conductivity, and that experimental attempts are being made to separate the turning moment due to this influence from the internal friction effect. The result arrived at is that in Stokes' formula $K = 6\pi\kappa RV$ (where K is the force acting upon a sphere of radius R with constant velocity V in a liquid of internal friction κ) the R (true radius) is replaced by R^* which is a function of the characteristic radius R_0 itself depending upon the properties of the liquid, the temperature, and the charge on the sphere. These R^* are for the alkali metals: Cs, Rb, K, Na, Li, 1·11, 1·12, 1·17, 1·74, 2·26; and the halogens I, (Br), Cl, 1·13, (1·12), 1·15, all × 10^{-8} cm. The (uncertain) true R are in the same sequence 0·83, 0·77, 0·69, 0·51, 0·45; 0·95, (0·77, 0·92), 0·73. The different methods of determining the R cannot but give different results, since the radii are defined in different ways. Further reference is made to the R_g (lattice, *Gitter*) radius and the R_w (heat of hydration) radius, and to the space-filling of Lorenz. H. B.